Space Weather Technical Forecast

Issued on Monday, 06 March 2023 at 13:24 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: M-class flares (R1-R2/Minor-Moderate radio blackouts) likely throughout with a slight of X-class flares. Chance of G1/Minor Storm intervals especially between 06 to 08 Mar. Electron fluence is expected to be Active.
Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate over the past 24 hours, with five M-class flares, the strongest of these an M5.7 at 06/227UTC from AR3243 close to the northwest limb. There are eleven sunspots on the disc, with the largest region is AR3242 in the northeast quadrant which contains a delta spot in the intermediate portion. AR3244 and AR3245 both appear to be developing but are still relatively simple magnetically. The remaining regions are also relatively simple and inactive. A CME have been observed leaving the Sun close to the southwestern limb in the last 24 hours and will be analysed as more data become available. A CME from closer to the western equator early on 06 Mar has been modelled and appears to be missing the Earth.

Solar Wind / Geomagnetic Activity: The solar wind as observed at L1 by DSCOVR, has varied between elevated and strong levels, reaching peaks of 625km/s. Density has been around average throughout. Total magnetic field strength was weak at close to 6nT, with the north-south component varying weakly between positive and negative directions. Phi angle was primarily negative (towards the Sun). Geomagnetic activity was Quiet to Active (with one G1/Minor Storm interval between 05/1800-2100UTC.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES16 remained at background levels. Electron flux at GOES16 has been mostly high with a peak of 6750pfu at 05/1620 UTC. Electron fluence has been above the Active threshold (1e8 integrated flux) during the period, with a value of 2.13e8 integrated pfu recorded at 06/0000UTC.

Four-Day Space Weather Forecast Summary
Solar Activity: Solar activity is forecast to be mainly Low to Moderate, due to the presence of a number of significant sunspot regions across the disc. There is a risk of Strong activity due to the complexity of two regions, AR3243 on the northwest limb and AR3242 in the northeast quadrant.
Solar Wind / Geomagnetic Activity: No significant Earth-directed CMEs feature in the current forecast, with only glancing blows possible between 06 to 08 Mar. A current coronal hole high speed stream is expected to wane through 06 and 07 Mar, with a further high speed stream possibly connecting on 08 Mar. Geomagnetic activity is expected to be mainly Quiet to Unsettled, with a risk of Active to G1/Minor storm intervals due mainly to any impactful CME glances. There is also a risk of G1/Minor Storm intervals on 08 Mar due to a high speed stream connection.

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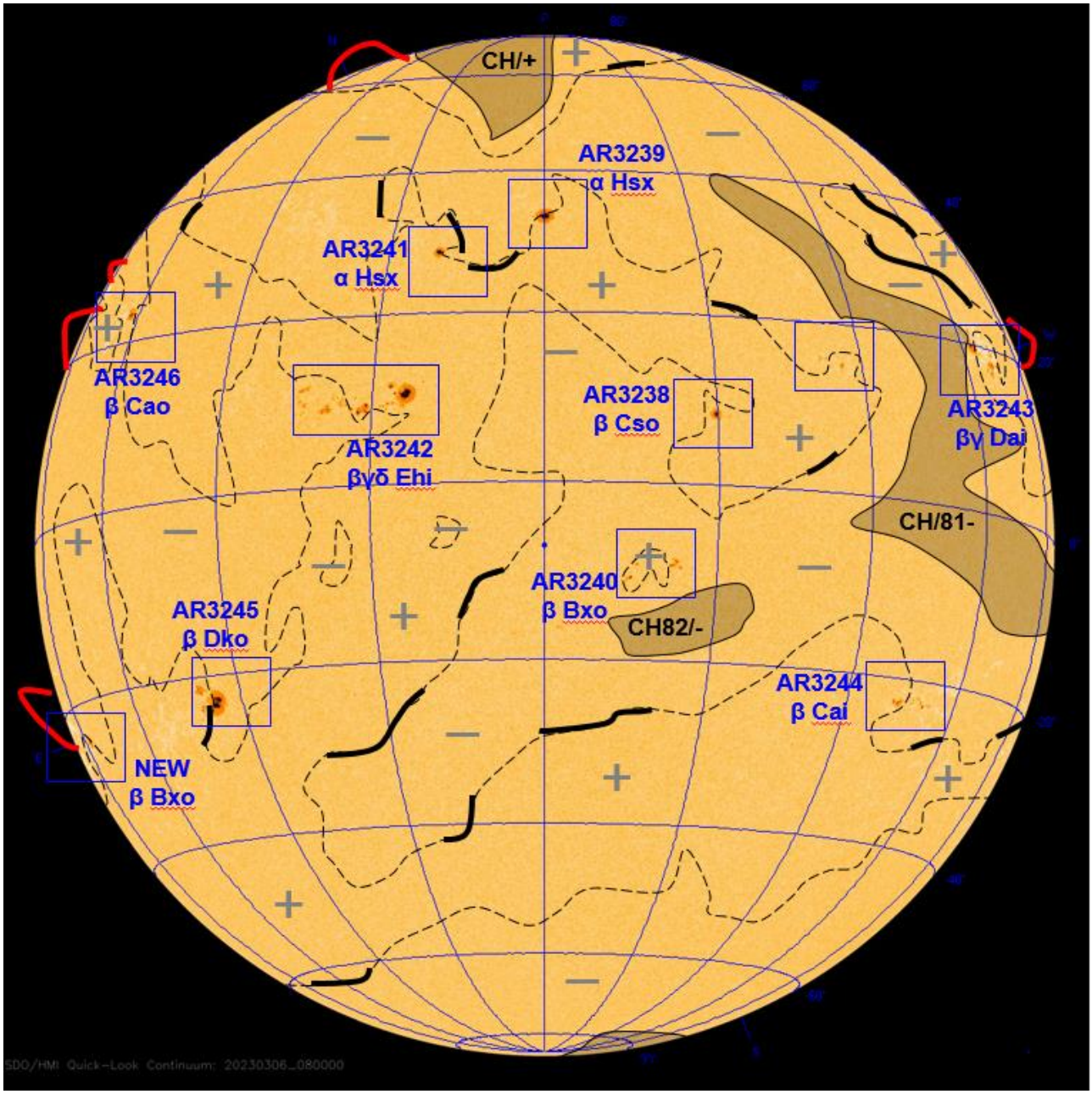
Met Office Space Weather Technical Forecast

Energetic Particles / Solar Radiation: High energy (greater than 10MeV) proton flux, as observed by GOES16, is currently at background levels, but with a slight chance of reaching S1 or greater should any larger flares occur. Electron flux is likely to continue at high levels but with uncertainty due to the possibility of CME glancing blows and a coronal hole high speed stream connection suppressing levels. Electron fluence is above the Active (1e8 integrated pfu) threshold, and is likely to remain above Active levels through the guidance period albeit with some uncertainty.

Figure 1. Solar Analysis Valid 06/0800UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:
There are two glancing CME effects forecast through the next four days. The first, from an X2.1 on 03 Mar is forecast to affect the near Earth environment on 06 Mar, but with low confidence. There is similar low confidence for a glancing CME which left the Sun on 05 Mar, which could glance the Earth on either 07 or 08 Mar. A further CME was observed leaving the southwest limb early on 6 Mar and will be analysed once further imagery becomes available.

Earth is currently under the influence of a high speed stream from large coronal hole 81 which is close to the western limb. The high speed stream is expected to wane through 06 and 07 Mar, but elevated winds are possible during the period due to the smaller coronal hole 82 which is just transiting centre disc and could connect on 08 Mar. As the Earth is approaching the March equinox, negative polarity coronal holes such as 81 and 82 are favoured for providing a strong geomagnetic response.

Geomagnetic activity is expected to be Quiet to Unsettled throughout the period, with a risk of Active or G1/Minor Storm intervals due to any significant CME effects or due to the connection of a coronal hole high speed stream from coronal hole 82.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	30	30	30	10
Strong	G3	No	5	5	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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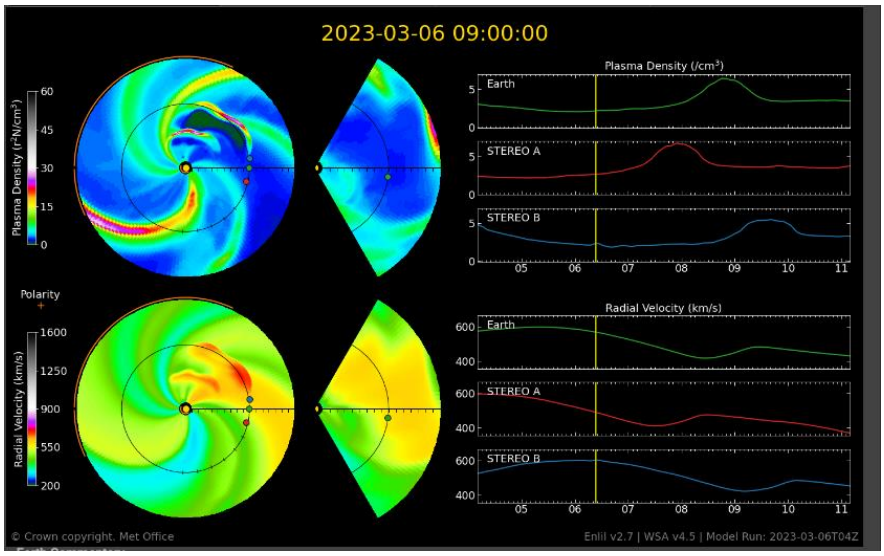
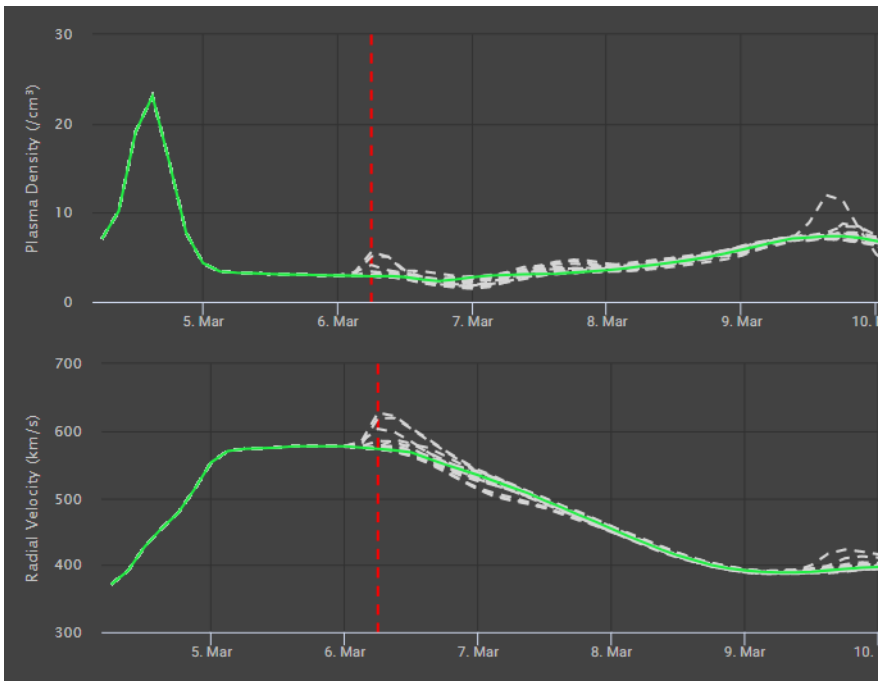
Figure 2: MOSWOC Enlil and Enlil ensemble models, showing a slight chance of glancing blows due to modelled CMEs





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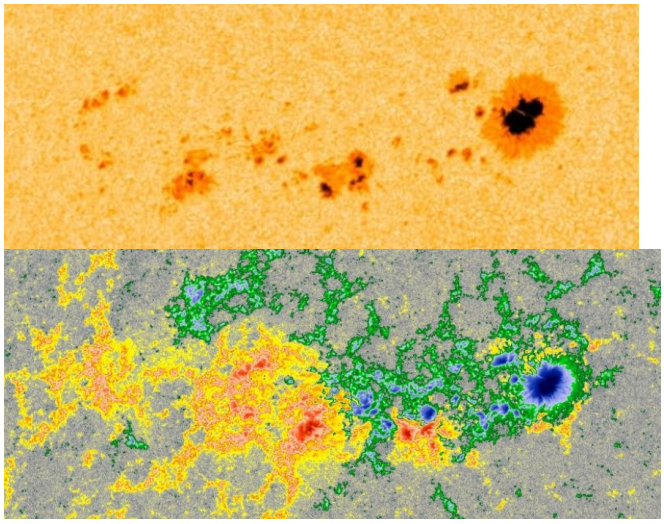
Radio Blackouts - X-Ray Flares:
There are eleven sunspots on the visible disc, with AR3242 in the northeast quadrant, the largest region with the highest risk of flares. AR3242 also contains a delta configuration in the middle of the region but has been relatively inactive with no recent significant flares. The most active region on the disc is AR3243 close to the northwest limb, which has produced two flares in excess of the M5 level and contributes significantly to the overall flare risk. The remaining regions are all relatively inactive, but AR3244 and AR3245 have shown modest signs of increasing complexity. The rotation of complex regions across the western limb through the period is likely to be balanced by the number of regions rotating onto the east, with risks kept relatively stable through the period.

Solar activity is forecast to be mainly Low to Moderate, with a risk of X-class flares throughout.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	60	60	60	60
Very Active	R3 to R5 X Class	No	10	10	10	10

Figure 3: SDO HMI and magnetogram imagery of AR3242 in the northeast quadrant



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Solar Radiation Storms - (High Energy Protons):
High energy (greater than 10MeV) proton flux, as observed by GOES16, is currently at background levels. AR3234 is now over the west limb, but will contribute a declining portion to the risk of S1 or greater events occurring through 06 Mar and perhaps into 07 Mar. In the meantime, AR3242 will be rotating towards centre disc, posing an increased risk of proton flux increasing with any larger flares, especially given the delta configuration. AR3243 in the northwest has also developed recently and was responsible for two flares in excess of M5 level, so this is now contributing a small amount to the risk of a proton event. Overall, the probabilities have been kept flat through the period with AR3242 taking over from AR3243 as the main risk area.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons Event (≥ 2MeV):
Electron flux is at high levels due to recent inputs from the coronal hole high speed stream. This is likely to remain elevated above the high threshold through much of the period, in the absence of any enhancements to geomagnetic activity. There is a risk of an increase in electron levels as the belts are currently charged at levels below GEO. As the high speed stream from coronal hole 81 eases and the belts relax, the populations at lower orbits could enhance the GEO electron counts, although the connection of coronal hole 82 on 08 Mar could inhibit this relaxation.

Electron fluence is expected to remain above the Active (1e8 integrated pfu) threshold, with a very slight risk of exceeding the Very Active threshold.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	Yes	100	90	80	70
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	5	5	5

Figure 4: GOES 16 electron flux and MOSWOC REFM models showing both high electron flux and Active electron fluence

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